

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE APR 2008		2. REPORT TYPE		3. DATES COVERED 00-00-2008 to 00-00-2008	
4. TITLE AND SUBTITLE Linear TWT Analysis for Sheet-beam Interaction				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Research Laboratory, Code 6841, 4555 Overlook Avenue S.W., Washington, DC, 20375				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM002087. Proceedings of the 2008 IEEE International Vacuum Electronic Conference (9th) (IVEC 2008) Held in Monterey, CA on April 22-24, 2008. U.S. Government or Federal Rights License					
14. ABSTRACT see report					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 2	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

10.2: Linear TWT Analysis for Sheet-beam Interaction

Simon J. Cooke, Baruch Levush

Naval Research Laboratory, Code 6841,
4555 Overlook Avenue S.W.,
Washington, DC 20375, USA
(simon.cooke@nrl.navy.mil; Tel: 202-404-4511; Fax:
202-767-1280)

Gregory S. Nusinovich

Institute for Research in Engineering
and Applied Physics, University of Maryland,
College Park, MD 20742, USA

Abstract: *We present initial results of a linear interaction theory for sheet-beam traveling-wave amplifiers, applied to broadband sheet-beam coupled-cavity amplifier structures.*

Keywords: Sheet beam amplifier; linear theory; traveling-wave amplifier

Introduction

Sheet-beam TWT amplifiers are inherently overmoded due to the necessarily large transverse dimension of the interacting structure. Their susceptibility to the excitation of high-order modes therefore increases as the aspect ratio gets larger and the mode density increases. A simple analytical small-signal theory for the sheet-beam TWT has been developed to provide a useful tool to analyze the effects of mode competition in this case. In principle, simultaneous interaction with several waves is possible in a high aspect-ratio structure and such waves can be cross-coupled due to the presence of a beam even in small-signal regimes. The present theory includes such interactions, however we consider here simple interaction with modes in isolation.

The strength of coupling between a bunched electron beam and a particular propagating mode depends upon both the spatial distribution of the beam and the electromagnetic field distribution of the wave. For a structure that is periodic along the beam direction, we characterize the interaction with a particular axial spatial harmonic of the electromagnetic field using the Pierce impedance, which is now a function of the transverse coordinate,

$$K(\bar{x}_\perp) = \frac{\left| \frac{1}{p} \int_0^p E_z(\bar{x}_\perp, z) e^{-i\beta z} dz \right|^2}{2\beta^2 P},$$

where p is the period, β is the axial wavenumber of the spatial harmonic and P is the power flow. If we represent the transverse normalized distribution profile of the electron beam current by $\Psi(x_\perp)$ then the effective impedance can be computed as the transverse overlap integral,

$$K_{eff} = \int_{s_\perp} \Psi(\bar{x}_\perp) K(\bar{x}_\perp) d\bar{x}_\perp^2, \quad \text{where} \quad \int_{s_\perp} \Psi(\bar{x}_\perp) d\bar{x}_\perp^2 = 1$$

By tailoring the beam distribution within the beam tunnel, it is possible to control to some extent the relative strength of coupling between the interacting mode and competing high-order modes.

Results

We show below results for two sheet-beam coupled cavity TWT geometries. Figure 1 shows the computed dispersion for a sheet-beam coupled-cavity TWT having a relatively small aspect ratio, and a single competing high-order mode. The plots show $K(x_\perp)$ computed using the upper half of the geometry for the interacting and high-order modes, respectively. The former has a central region of uniform impedance, desirable for uniform interaction, while the latter exhibits a central zero, since its field is anti-symmetric across the beam. Relative coupling to the high-order mode will therefore increase for higher beam aspect ratios in this structure. Each mode exhibits strong coupling in the vicinity of the metal structure at the edges of the beam tunnel, due to the evanescent nature of the fields in the slow-wave structure.

Figure 2 shows results of a similar study for a high aspect-ratio TWT structure. The dispersion curves computed for this structure show a large number of potentially competing high-order modes. The interacting (fundamental) mode again exhibits a wide central region with relatively uniform impedance, even for a large aspect ratio beam. However, there are now many more high-order modes to evaluate, each having a different transverse field structure. The lower plots show the computed impedance profiles for the first three, exhibiting one two and three zeros respectively.

Conclusion

We demonstrated the spatial dependence of the interaction impedance for fundamental and high-order modes in sheet-beam interaction structures, using a linear theory for sheet-beam amplifiers. The computed impedance profiles will form the basis for an analysis of the dependence of the small-signal interaction characteristics of competing modes, as a function of the beam current spatial distribution profile.

Acknowledgements

This work was supported by the U.S. Office of Naval Research.

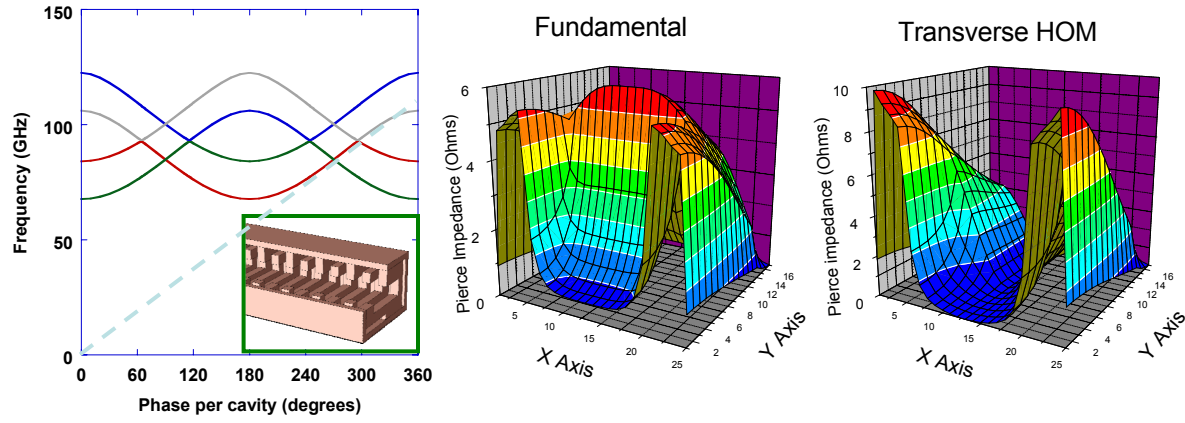


Figure 1. Dispersion curves and transverse spatial distribution of the Pierce impedance for the fundamental and high order mode of the low aspect ratio sheet-beam TWT. (Phase advance per cavity, 230°).

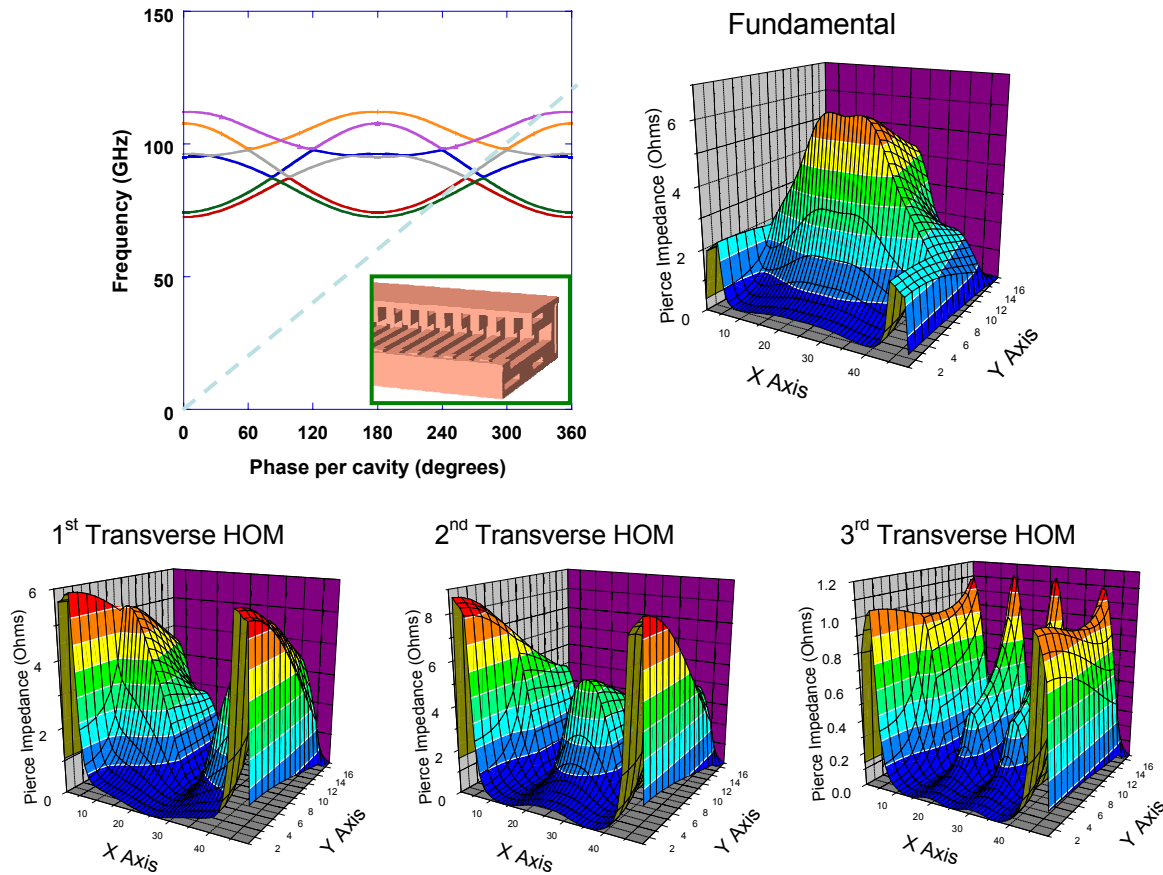


Figure 2. Dispersion curves and transverse spatial distribution of the Pierce impedance for the fundamental and high order modes of the high aspect ratio sheet-beam TWT. (Phase advance per cavity, 230°).